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MARINE CORPS IT HARDWARE: A METHOD FOR CATEGORIZING AND DETERMINING TECHNOLOGY REFRESHMENT CYCLES

by

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June 2015

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ABSTRACT

Management of information technology (IT) assets within an enterprise is necessary to control organizational costs and ensure that the necessary business requirements are supported. For over 10 years, the Navy Marine Corps Intranet (NMCI) was charged with this task in Navy and Marine Corps IT systems. With the expiration of the NMCI contract, the Marine Corps is now managing its own IT assets. To understand the scope of IT assets to enable better management, this research explores items accounted for within the master data repository, which is aiding in the migration of legacy logistics systems to GCSS-MC. These items and their associated costs are divided into categories to provide a baseline view of Marine Corps IT hardware assets. An equivalent annual cost is applied to assets to suggest a refreshment cycle for laptops, desktops, and servers. This demonstrates a method that can provide IT managers with a means of determining when an asset should be refreshed.

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LIST OF ACRONYMS AND ABBREVIATIONS

C4	Command, Control, Communications and Computers Command
CI	configuration items
CMDB	configuration management database
COTS	commercial-off-the-shelf
DITPR-DON	Department of Defense Information Technology Portfolio Registry—Department of the Navy
DOD	Department of Defense
DOD CIO	DOD Chief Information Officer
DON	Department of the Navy
DON CIO	Department of the Navy Chief Information Officer
DPAS	Defense Property Accountability System
EAC	equivalent annual cost
EAPR	enterprise asset posture report
GCSS-MC	Global Combat Support System-Marine Corps
IT	information technology
IT/NSS	Information Technology and National Security System
ITIL	Information Technology Infrastructure Library
LAN	local area network
MCHS	Marine Corps Common Hardware Suite
MCPC	Marine Corps Programming Code
MDR	master data repository
NDI	non-developmental item
NMCI	Navy Marine Corps Intranet
NPV	net present value
NSN	national stock numbers
OMB	Office of Management and Budget
P&R	Programming and Resources Command
PA&E	Program Assessment and Evaluation Branch
PBDD	Programming and Budgeting Documentation Database
PBIS-IT	Programming Budgeting Information System-IT
PC	personal computer
POM	program objective memorandum
PPB&E	Planning, Programming, Budgeting and Execution

ROI	return on investment
SABRS	Standard Accounting, Budgeting and Reporting System
TAMCN	table of authorized material control numbers
TFSMS	Total Force Structure Management System
TLCM-OST	Total Life Cycle Management-Operational Support Tool

I. INTRODUCTION

A. BACKGROUND

In the past 20 years, information technology (IT) structures and functions have become vital to the daily operations of all organizations. The size and scope of the organization may vary from a few employees located at a single location to thousands of employees located around the globe. IT infrastructures have provided a means for these organizations to function efficiently, as well as enable employees around the world to work and collaborate. The benefits of a well-designed enterprise IT strategy have been well documented (Joia, 2003).

Enterprise technology, information, and infrastructure refer to the concept of IT resources and data shared across an enterprise. In this case, the term enterprise is used to mean across a sponsor's entire organization. It is not limited, however, to just one organization, as the term can be applied to cross-organizational systems, such as joint or Department of Defense (DOD) enterprises.

In government organizations, a great emphasis is placed on identifying areas of large financial expenditure and determining where cost-saving techniques could be applied. The Department of the Navy, and within it the Marine Corps, is tasked by the DOD Chief Information Officer (DOD CIO) with capturing an accurate determination of its expenditures across a wide spectrum of programs. This task includes an examination of the Marine Corps IT portfolio and its overall monetary value and cost for maintenance. One challenge is that current planning and programming processes do not always identify IT investments, and do not allow programmers to possess the detailed information required to make trade-off decisions among IT investments.

The DOD information enterprise provides a strategic architecture from which to govern and integrate information systems (DOD Chief Information Officer [DOD CIO], 2012). It also provides the governance from which IT decision makers can prioritize the needed capabilities by analyzing the state of the enterprise, identifying capability gaps, and determining appropriate investments to fill those gaps. They can then use these

investments to establish performance metrics and feedback to aid in making future acquisitions (DOD CIO, 2012). IT management is not a purely technical issue, which is demonstrated by the abundance of competing IT effectiveness, efficiency, and accountability methods (Melitski & Yang, 2007). The challenge faced by IT managers is to have a strategy that improves innovation, flexibility, efficiency, and visibility of acquisitions processes to better make decisions (Halverson, 2012). By using a total-cost-of-ownership concept, IT inventories can be maintained efficiently and decision makers will have the necessary data to determine the most effective way to manage the enterprise.

This thesis identifies sources of information necessary to create an accurate inventory of Marine Corps hardware IT assets and its categorization and quantification. This categorization and quantification is then analyzed to apply a monetary evaluation to the inventory. These data are used to evaluate appropriate IT expenditures in future programming and budget cycles as an aid to providing flexibility regarding the Marine Corps IT inventory. Although it is not possible within the scope of a single thesis to analyze and categorize the entire Marine Corps IT enterprise, this thesis offers a methodology for future research and analysis.

This research examines existing frameworks and methods to determine a reasonable and repeatable approach that is beneficial to the Marine Corps. An evaluation of technology categories is made by using commercial best practices and DOD-specific requirements. The financial evaluation of the inventory used procurement-cost data from several databases to determine the replacement cost of assets. A recommended technology-refreshment cycle is determined by evaluating the total cost of ownership of hardware assets.

Three research questions are addressed for the Marine Corp IT portfolio.

- How should IT hardware assets be categorized?
- What is the monetary value of currently fielded IT assets?
- At what frequency should the inventory be refreshed with more current and capable technology?

B. THESIS ORGANIZATION

Chapter II provides an overview of literature on the factors that affect procurement and management with a focus on technology-refreshment cycles. Chapter III presents the methodology used in this research to answer the research questions. Chapter IV shows the analysis of the data. Chapter V draws conclusions of the analysis from Chapter IV and provides recommendations for implementation and future research.

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II. LITERATURE REVIEW

Information is a strategic asset and effectively managing the systems that process, store, and transmit it is essential to realizing its inherent value. The DOD provides strategic enterprise architectures from which to govern and integrate information systems (DOD CIO, 2012). Decision makers analyze shortfalls or gaps in current IT capabilities and systems, and then prioritize the required capabilities to plan investments to fill those shortfalls and gaps. Understanding the factors that affect the development of an IT technological refreshment cycle requires an understanding of the building blocks used in the process (Takai, 2012b). This section reviews factors that provide scope and understanding of the digital hardware for the Marine Corps enterprise and provides information to contribute to the planning and management. The proper categorization of technology assets must be both logical and functional so that the information is useful when making programming decisions. Understanding the programming and budgeting processes and their interactions with the acquisition process is necessary to forecast future year expenditures and requires a method to predict potential future requirements. Finally, in determining the best technology refreshment cycle to be utilized, it is important to understand that varying opinions have been proffered on the best way to determine a technology refreshment cycle within an organization. Notwithstanding these differences, all require a structured system that allows for data collection and analysis to provide decision makers with the necessary data.

A. CATEGORIZING ASSETS

In an article concerning IT and the classification of assets, Rajakrom, Chandarasupsang, Harnpornchai and Chakpitak (2006) examined the thought process behind how individuals and groups generally classify new objects presented.

Ideally, a category will illuminate a relationship of the subjects and objects of knowledge. In the article, he describes two models by which to categorize assets. The ontological model focuses on defining a set of data and its structure for someone else to use.

- In their study, it would relate to establishing overarching categories, such as computers, servers, etc.
- The object-oriented model deals with the physical and conceptual objects, such as laptops and external hard drives. An object has a state, exhibits a well-defined behavior, and has a unique identity.

Hampton, Dubois, and Yeh (2006) determined that the vagueness of a category can lead to uncertainty and erroneous categorization of objects, depending on the category name. This potential fault illustrates the requirement to have clearly defined categories, so that objects may be correctly placed into appropriate categories. It is also important that the context of categories is well defined, so as to allow for the correct grouping of objects. If the broad category is too vague, the likelihood of consistent categorization by a sample group is diminished. Possible solutions require applying a clear and specific context to the category and the objects or developing a detailed list of criteria for each category.

1. What Is Information Technology?

Within the federal government, four different definitions of information technology can be applied to the Marine Corps enterprise.

United States Marine Corps:

> Any equipment or interconnected system or subsystem of equipment used in the automatic acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information, including computers, ancillary equipment, software, firmware and similar services and related resources whether performed by in-house contractor, other intra-agency or intergovernmental agency resources/personnel. Both system and non-system IT resource including base level units (communications, engineering, maintenance, and installation) and management staffs at all levels are included in IT resource reporting (Marine Corps Order 5230.21, 2012, p. 17).

Department of the Navy:

Any equipment or interconnected system or subsystem of equipment that is used in the automatic acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission or reception of data or information by the DOD Component. For purposes of the preceding sentence, equipment is used by a DOD Component if the equipment is used by the DOD Component directly or is used by a contractor under a contract with the DOD Component that (Deputy Secretary of Defense, 2010, p. 11):

1. Requires the use of such equipment; or

2. Requires the use, to a significant extent, of such equipment in the performance of a service or the furnishing of a product. The term "information technology" includes computers, ancillary equipment, software, firmware and similar procedures, services (including support services), and related resources. Notwithstanding the above, the term "information technology" does not include any equipment that is acquired by a Federal contractor incidental to a Federal contract.

Department of Defense:

Any equipment or interconnected system or subsystems of equipment that is used in the automatic acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information, and includes (Coordination of Federal Information Policy, 2012, p. 143):

(A) computers and computer networks

(B) ancillary equipment

(C) software, firmware, and related procedures

(D) services, including support services; and (E) related resources.

Clinger-Cohen Act of 1996:

The term Information Technology, with respect to an executive agency means any equipment or interconnected system or subsystem of equipment, that is used in the automatic acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information by the executive agency. For purposes of the preceding sentence, equipment is used by an executive agency if the equipment is used by the executive agency directly or is used by a contractor under a contract with the executive agency which (i)

> requires the use of such equipment, or (ii) requires the use, to a significant extent, of such equipment in the performance of a service or the furnishing of a product. Information technology includes computers, ancillary equipment, software, firmware and similar procedures, services (including support services), and related resources. It does include any equipment that is acquired by a Federal contractor incidental to a Federal contract (Clinger-Cohen Act, 1996).

These definitions are broad in scope and do not provide specific guidance on the how to categorize IT assets effectively within an enterprise, so that individual systems can be effectively tracked and managed. In an effort to manage these broad systems better, the Department of the Navy Chief Information Officer (DON CIO) issued a memorandum in 2013 clearly defining system level categorization of IT assets (Halverson, 2012).

In an effort to enhance the DON’s ability to track IT assets and aide in the reduction of IT costs, the DON CIO defined categories of IT assets (Halverson, 2012). The Programming Budgeting Information System-IT (PBIS-IT), from which annual IT investments are tracked and reported, organized assets by specific line numbers. The categories differentiate between new purchases and leases, and provide amplifying guidance by line item of which items are to be identified under the broader category of new or leased. The increase in detailed guidance will enable a universal understanding of how to categorize IT assets

Subsequently, the Marine Corp Programming and Resources Command (P&R) and the Marine Corps Command, Control, Communications and Computers Command (C4) developed a list of system-specific categories to be tracked. These categories are applied to facilitate internal accountability of systems, as well as to aid in acquiring reporting data for budgetary information systems. The next section discusses best practices identified in the commercial sector on establishing systems to manage and maintain IT assets appropriately.

2. Configuration Management

The Information Technology Infrastructure Library (ITIL) was formed as a result of the British Office of Government Commerce being tasked with developing an approach for the efficient and cost-effective use of IT resources by British public sector

organizations. The aim of the ITIL was to develop a collection of best IT practices for managing, monitoring, and maintaining IT enterprise hardware, software, and services independent of any supplier (Office of Government and Commerce [OGC], 2005). Organizations, such as Hewlett-Packard, IBM, and Microsoft have used the frameworks outlined by the ITIL when developing their IT service management processes (OGC, 2005).

The ITIL uses configuration management to describe the management of acquisitions, maintenance, and monitoring of IT components within the infrastructure. Configuration items (CI), such as computers, printers, servers, storage, networking hardware, and software are identified, and their information is collected and stored in a configuration management database (CMDB). It is necessary to identify the scope (breadth) of what is to be included in the database, level of components breakdown (depth) and the level of detail to have a database that will allow for appropriate configuration management. It is often helpful to group similar items within the database that are of common types or functions to manage their unique configuration requirements as a part of entire enterprise system (OGC, 2005). The use of these frameworks can help to determine the appropriate breakdown of individual assets and services within the enterprise and aid in their management across many functional areas.

In an effort to begin managing its IT infrastructure along the lines of what is recommended by the ITIL, in 2006, the DOD CIO mandated the registration of all IT related assets and services into a common, DOD-wide database, the Department of Defense Information Technology Portfolio Registry—Department of the Navy (DITPR-DON). The DITPR-DON is intended to be the single authoritative source for data regarding IT systems within the DON. Each service is required to maintain a similar database with similar information. Its purpose is to facilitate the basic IT asset management tasks of registering, transferring, and archiving DON IT systems, as well as to provide senior decision-makers with the context and key information necessary to support IT investment decisions.

A GAO 2012 report found that the IT registry databases were mission-critical and mission-essential information systems, and allowed each DOD component to determine

whether systems should be reported as mission-critical or mission essential. However, this method did not accurately capture the universe of information systems (Melvin, 2012b). The information contained in the system was limited to systems of systems and families of systems and did not provide detailed information concerning individual systems, such as laptops, desktop, routers, and firewalls, etc. Mission-essential systems are primarily systems that are a collection of individual assets that provide a specific function; individual system components are not tracked independently.

The Marine Corps has fielded a series of automated computer systems intended as stand-alone independent systems for logistics. The systems used to account and manage IT assets are the Standard Accounting, Budgeting and Reporting System (SABRS), the Total Force Structure Management System (TFSMS), and Defense Property Accountability System (DPAS). The TFSMS and DPAS systems account for the physical hardware assets, while SABRS accounts for costs associated with supporting those assets (J. Castro, personnel communication, January 30, 2015).

Beginning in 2011, the Global Combat Support System-Marine Corps (GCSS-MC) began implementation to become the central enterprise-wide logistics management tool. To accomplish this integration of data from legacy systems, it was essential to manage effectively the systems accounted for in previously stand-alone databases. This requirement was met with the development of the master data repository (MDR) as the consolidated data repository for utilization by the GCSS-MC. This central data warehouse loads data from 31 separate source systems, approximately 53 million records daily, to include data from DPAS, TFSMS, and SABRs. This information is then used to populate eight different databases that support the Total Life Cycle Management-Operational Support Tool (TLCM-OST), which provides a system-agnostic reporting environment that shields individual users from having to know which authoritative data source provides the displayed information. Figure 1 graphically depicts some of the input sources and output data provided to and from the MDR.

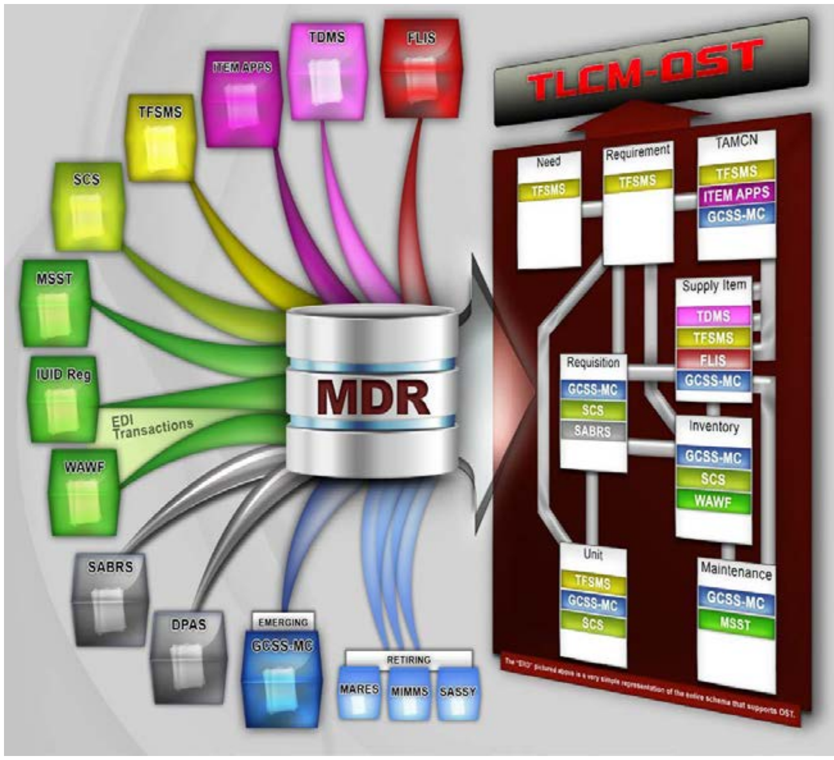

Figure 1. Depicts How the MDR Is Populated and Used (from Hiles, 2013)

Within the MDR, items are identified by unique table of authorized material control numbers (TAMCN). Each material item within the Marine Corps inventory is assigned a TAMCN and is initially divided into major commodity categories with a commodity designator as indicated.

- A—Communications and Electronics
- B—Engineering
- C—General Supply
- D—Motor Transport
- E—Ordnance

Within the commodity designator, each type of equipment is identified with a unique code. To provide further detail within the TAMCN, national stock numbers (NSN) are used by the federal government to identify individual items by type, manufacturer number, and unit price. Multiple NSNs can be applied to the same TAMCN. These data fields are populated into an enterprise asset posture report (EAPR) that provides NSN level item data and total on-hand counts of equipment, at the unit level for all units in the Marine Corps. Each NSN is listed with its procurement cost and the number on-hand to

provide for a total asset level accounting of items assigned with a TAMCN within the Marine Corps.

B. COST DRIVERS AND PLANNING

1. Acquisitions and Budgeting

The rapid pace of technological change does not match well with the federal government's budget formulation and execution process. An issue unique to the acquisition of IT systems is the rate at which technology obsolescence occurs. The acquisitions timeline for major programs routinely requires in excess of five years to field new systems. Due to the per year increase in the capabilities of technology, these systems are often outdated by the time they are acquired and deployed for use (Yen-Chou, 2013).

To compensate for this long timeline, IT budget items are required to be forecast several years in advance with an anticipated future cost and have limited flexibility for current year expenditure authorizations (Department of Homeland Security, 2010). Estimating the future costs of systems requires accurate and credible cost estimating. The Government Accountability Office specifically defines an accurate and credible cost estimate with the following criteria (Melvin, 2012a).

- Comprehensive: Accounts for all possible costs associated with a program, structured in sufficient detail to ensure that costs are neither omitted nor double-counted, and documents all cost-influencing assumptions.
- Well Documented: Documentation explains the process, source and methods used to create the estimate. Contains underlying data used to develop cost estimates and is adequately reviewed and approved.
- Accurate: Not overly conservative or optimistic, based on an assessment of costs most likely to be incurred and is updated regularly.
- Credible: When limitations of the analysis because of uncertainty or sensitivity surrounding the data are discussed, the estimated results are cross-checked by a group outside the acquiring organization.

IT strategy is a comprehensive roadmap on how IT will accomplish the objectives and principles of the organization (Housel & Bergen, 2013). Values such as efficiency and accountability should be addressed in the strategy, especially for government. Metrics need to monitor effectively the effects of systems on productivity and encompass benefits to users (Rojo, Roy, & Shehab, 2010). Accomplishing the strategic goals

outlined by the DOD CIO can be done by applying costing metrics against system cost and life performance (Takai, 2012a).

Enterprise asset managers periodically evaluate IT investments to ensure the system is providing the required support (DOD CIO, 2012). Several evaluation methods include net present value (NPV), return on investment (ROI), information economics, equivalent annual cost (EAC), and cost-benefit analysis, all of which provide a framework to quantify the benefits and risks (Zandi & Tavana, 2011). Evaluation of systems should be part of the functional strategy and align with the overall objectives. The desired information system should be evaluated by measurable and observable goals (Office of the Deputy Chief Management Officer [DCMO], 2013). Reduction of life cycle costs are generally the goal and are usually accomplished through the reduction of staff, better inventory control, and duplicate-system elimination (Olson & Wu, 2011). Other metrics could include potential benefits such as better output, increased capabilities, and decreased direct and indirect costs. The consistency of the cost-to-benefit ratio is desirable so that the ratio does not vary significantly over time (Kang, 2007). Costs associated with a system can be important drivers in determining which system is the best value over a suggested period. Many different metrics can be considered. It is important that managers ensure performance measures that are directly tied to enterprise strategy (DCMO, 2013).

2. Planning, Programming, Budgeting and Execution

Planning, Programming, Budgeting and Execution (PPB&E) is the process by which services and program sponsors within the DOD obtain and execute resources. PPB&E produces a department-wide resource plan that extends six years into the future (MCO 7300.21A, 2008). This four-phased process is designed so that two or more phases are occurring during any given fiscal year. During the programming phase, the joint programming guide created in the planning phase is used to develop the program objective memorandum (POM), which includes an analysis of missions, objectives, and alternative methods to accomplish objectives and which allocates resources for the next

six fiscal years. The key to the development of the Marine Corps' submission to the POM is the Marine Corps Programming Code (MCPC).

The MCPC is used by the Programming and Budgeting Documentation Database (PBDD) for resource categorization and tracking. The MCPC groups similar functions, regardless of appropriation, for funding decisions. Therefore, they attribute expended funds against an activity or command and not necessarily against the physical item being purchased or funded. For example, if a laptop computer is purchased as a Global Combat Support System—Marine Corps (MCPC 111102), the cost is not categorized as a laptop computer purchase but as a purchase against the MCPC. As a result, it becomes difficult to capture an accurate vision of IT spending.

The FY13 PBIS-IT report, which uses information taken from the PBDD, was submitted by the DON to the DOD CIO and identified $1.55B in IT investments. This number amounted to 5.5% of the total obligation authority for the Marine Corps that year (Laboy, 2014). Of the $1.6B in IT investments, the Marine Corps Program Assessment and Evaluation Branch (PA&E) determined through 96 identified IT product service codes evaluated on www.usaspending.gov that $516M was allocated to hardware investments (USMC IT Strategy Advisory Support Group, personal communication, October 24, 2014). Of all the IT investments captured by the Marine Corps, hardware accounted for 33% of the total captured IT investment.

Both the study conducted by PA&E and an analysis of the PBIS-IT for FY14 conducted by the Marine Corps Information Technology Issue Team concluded that not all IT assets investments are captured in any single database. This data collection challenge has limited the Marine Corps' ability to capture all IT investments accurately. This inability to capture all investments, coupled with an associated rise in annual IT spending over the last 12 years, makes it difficult to determine an appropriate cost point for annual hardware asset purchases (Nally, 2011).

In an effort to track IT purchases better and fund purchases within a single MCPC, the Marine Corps Common Hardware Suite (MCHS) was created as a program of record (Nally, 2011). Under this program, the Marine Corps Information Technology and

Strategic Sourcing team conducts detailed market research annually to identify hardware solutions that meet user requirements for function and sustainment. This program is an indefinite delivery/indefinite quantity, multiple-award contract for commercial-off-the-shelf (COTS) computer systems. MCHS is intended to provide common computing platforms and global logistics support for hardware purchases. It leverages economies of scale to reduce hardware prices by sourcing all purchases from an approved list of vendors. All vendors under the contract have agreed to a pairing of hardware pricing and configuration. All systems come with a four-year warranty that covers all manufacturers' defects and is intended to coincide with the intended refresh cycle of the systems (J. Castro, personal communication January 30, 2015). It will provide greater standardization of hardware across the enterprise and consolidate hardware purchases to a specific MCPC.

C. TECHNOLOGICAL REFRESHMENT CYCLE CONSIDERATIONS

Asset life cycle planning is a critical aspect of maintaining and expanding the capabilities of an enterprise. The definition of technology refresh from DOD Instruction (DODI) 5000.02 is the periodic replacement of both custom-built and COTS systems, within larger DOD weapon systems, to assure continued supportability through its life cycle (DOD, 2015). In this research, the weapons system will be the Marine Corps enterprise architecture. Technology refreshment can also be defined as the intentional incremental insertion of newer technology into existing systems to improve reliability and maintainability or to reduce cost typically in conjunction with normal maintenance. Being intentional requires deliberate planning for resources, schedule, reliability, and maintainability considerations by the program management office. It is worth noting that in the second definition, technology refreshment is typically done in conjunction with normal maintenance (Yen-Chou, 2013).

The technological refreshment rate of an organization was defined by Haines (2001) to include off periodic replacement of COTS systems within larger DOD systems to assure the continued supportability of that system through an indefinite service life. Technology refreshment should be planned into systems early in their life cycle because

technology refreshment will require commercial standards-based architecture to maximize COTS refreshments. To build technology refreshments into the design of the system, Stavash, Sharma, and Konicki (2006) identified three types of technology management.

- Technology Upgrades: A change that incorporates the next generation component and is usually to maintain consistency of form, fit and function.
- Technology Refresh: A change that incorporates a new component to avoid obsolescence that may require form, fit, and function recertification.
- Technology Insertion: A change that incorporates a new component as the result of additional requirements or advance development. Technology insertion will not have the same form, fit, or function, and may require redesign of the next higher assembly.

Within an organization, it is likely that technological refreshment requirements will occur in all three types of technology management. Anticipation of the costs associated with each type of management strategy will vary depending on the scope of the project and the desired operational end state of the system. From an acquisitions standpoint, these types of technology management are often lumped together, even though each has differing effects on budgeting and acquisitions cycles (Yen-Chou, 2013).

Several factors can drive and even shape technology refreshment within organizations. Pathak (2011) identifies key drivers that he has observed to shape the timing, extent and cost of technology refreshment cycles:

- Aging/obsolete technology—The lack of a proactive approach to technology assessment provides little forward planning and goes unnoticed as long as the equipment meets the current purpose. These legacy systems often become heavily customized and make migration to new technology even more difficult.
- Unsupported technology—The longer outdated technology is used, attainable support from the manufacturer decreases.
- Skill set shortage—As technology advances, focus shifts to newer, more advanced systems, which can lead to a shortage in people familiar with a legacy system.
- Compliance—Regulatory compliance is mandatory for all organizations. With the changing digital landscape and shifting security concerns, legacy systems may no longer provide the required level of compliance for security restrictions.

- Cost reduction—A proactive technology refreshment plan can lead to reductions in overall life cycle costs of IT systems.
- Standardization—Due to requirements to consolidate functionality between organizations or business units, requires that technology be standardized to facilitate interoperability. Technology refreshment can be used as a strategy to mitigate interaction with different technologies.
- Innovation—Organizations look for innovations to improve their competitive positions. Technology refreshment can be used as a way to migrate to more competitive systems.
- Vendor stability—Shifts in the stability of a vendor can require technology refreshment to maintain a supported system.

These points are similar to those of the *Integrated Product Support Element Guidebook* section that covers continuous modernization and improvement. The use of performance standards, COTS/non-developmental item (NDI) preferences, commercial specification standards, and open systems architecture will be helpful in modernization. New technologies can be introduced rapidly to meet new requirements with continuous modernization that anticipates obsolescence, emerging requirements, and ensures new technologies are available to meet emerging requirements (Defense Acquisition University [DAU], 2011).

In most cases today, technology refresh is managed in a reactive manner. Organizations tend to treat these investments as capital expenditures and based on their performance, earmark a certain percentage of their budget for a technology refresh initiative (Pathak, 2011). The process of technology refresh within an organization usually occurs through the notification of an obsolete piece of equipment, the selection of a solution, the budgeting for the replacement, and the implementation. The time required in each phase of this sequential process can vary, but the timeline is usually quite long. In a dynamic marketplace, the system fielded for refreshment is unlikely to deliver the desired results (Pathak, 2011).

To provide for a more strategic technology refresh plan, Pathak (2011) suggests a more deliberate process is required for managing technology refresh at the enterprise level. This process is comprised of five phases that analyze the enterprise to develop a strategy. During the determination phase, a methodological process is conducted to gain an awareness of the current IT situation. The design phase determines the vision and

objective of the technology refresh program. The overall technology-refresh strategy is determined by doing a cost-benefit analysis of different refresh options. Key costs to examine when conducting the cost-benefit analysis are the new acquisition costs and the ongoing maintenance and support costs of the new systems (Pathak, 2011). The development phase determines the roadmap for the solutions derived from the design phase. It involves the planned implementation and required testing or proof-of-concept determination. The final phases are deploy and deliver. Theses phases conduct the rollout plan and any required training, as well as provide feedback as to the effectiveness of the refresh. This integrated approach is an ongoing process that provides an overall strategy for the implementation of technology refreshment strategy.

1. Hewlett-Packard Recommendations

Technology refreshment involves many aspects and considerations. The answer to the question "how often" depends on the needs of an organization (Michelson, 2013). Often, the greatest detractor to establishing an effective and efficient technology-refresh cycle is when the focus shifts from that of technology and capability to the budget. While budgetary considerations are always a factor, delaying technology refreshes can lead to an even greater expenditure in later budget years on IT.

Having identified that extending the life of technology platforms to realize short-term savings can lead to greater costs in later year IT budgets, Michelson (2013) identifies suggested life cycle considerations for desktops and notebooks.

2. Desktops

A desktop's useful life typically ranges from three to four years. Three years in optimal because it is typically during the third year when warranty windows expire, and the chipsets are still operating for a reasonable period for operating system performance and application performance. Although the system may continue to function well beyond this period, increases in out-of-warranty maintenance could increase the cost of ownership of the device.

3. Notebook PCs

The typical life cycle for a notebook is three years, which is shifting closer to a 30-month refresh window as battery technology and chipset improvement continues.

Organizations, when discussing technology refreshment, often explore the possibility of upgrading existing hardware with more capable internal components rather than purchasing new systems. Acquiring new devices is more costly than merely adding more disk memory or a new battery to existing devices (Michelson, 2013). However, the associated costs of actually having the new component installed, the old component disposed of, and maintenance records and systems updated, can make the cost of the upgrade very similar when compared to the purchase price of a new system (Michelson, 2013). Finally, adding more disk and memory to an older configuration might not extend the device life much longer since the device may still need to be replaced shortly anyway.

4. Intel Case Study

A study conducted by Intel Corporation examined the comprehensive cost of ownership of personal computer (PC) assets within the company. In a fiscally constrained environment, the common practice was to delay PC upgrades; however, the long-term implications of this short-term cost savings was unclear. Mahvi and Zarfaty (2009) examined the EAC of over 90,000 PCs within the company to allow them to arrive at an effective and valid comparison of refresh cycle options.

To determine the investment cost, the researchers examined several cost components that would occur annually with a system, such as help-desk support and software patches. It became evident to the research team that typically analysts rely on Net Present Value (NPV), a means of analyzing the profitability of an investment project, when making investment decisions. This approach examines the investment in terms of ingoing and outgoing cash flows over a period of time, and can determine whether an investment will be profitable for the company over the term of the project. This approach can have problems when comparing different refresh cycles and time horizons (Mahvi & Zarfaty, 2009). Typical IT investment decisions compare whether to invest in a new technology or not. With refresh cycles, the question becomes “how often” and not “if.”

To overcome this problem, costing data was used to identify the cost per year of owning a PC over its entire lifespan. This model is useful when trying to determine the total cost to own an item over a lifespan and identifying when the cost to own the PC begins to increase. After examining the calculated EACs over a five-year period, the researchers determined that the cost to own a PC began to increase after the three and a half-year mark. Thus, three and a half years was determined as the technology-refresh cycle for PCs at Intel. The detailed cost model revealed that delaying PC deployments shifts the costs into later periods and fails to optimize cash flow (Mahvi & Zarfaty, 2009).

The total cost of a PC is higher in the first year than in the fifth year when examining the uneven cash flows required to operate and support the PC. The cost to acquire, operate and support a PC in the first year in this study was $1,369. The cost to operate and support the same PC in the fifth year was $503. Considering only the uneven cash flows, it seems beneficial to continue operating this PC as long as possible because even with increasing operating and support costs, it is still less costly than a new acquisition year. However, by using an EAC to convert the uneven cash flows to smooth, regular cash flows, the total-cost-of-ownership of a PC can be shown over different life cycles. This provides a means for comparing the costs incurred over varying life cycles to determine the optimal time to replace them.

NPV and EAC are methods of discount cash-flow investment evaluation to aid in determining total costs of investments. In the NPV method, cash flows are discounted to the present dollar value while the EAC method converts cash flows into an equivalent series of uniform amounts. NPV computations often result in a large dollar amount that may be misleading. EAC expresses the dollar amount in a context that may be more meaningful to a decision-maker in organizations that report their activities on an annual basis (Jones & Smith, 1982). By capturing the annual operations and support cost of systems, the total cost over the intended period of employment can be determined. This cost can offer valuable insight in terms of system ROI (Jones & Smith, 1982).

EAC is dependent on the calculation of a discount factor. This factor is determined by using the discount or interest rate and number of periods to be covered (periodically, annually, etc.). The discount rate reflects the degree to which both costs

and benefits in the future are less valuable than costs or benefits today. Discount rates are measured in terms of the value in currency today of a good versus the delivery of that good at some time in the future. The discount rate measures the relative value of a good over time measured in current-year dollars (Wise & Cochran, 2006).

The discount rates can vary from industry to industry and organization to organization. Several different models are used to determine the discount rates to be used in NPV and EAC calculations. A building block to determining the discount is the risk-free rate. An investment is risk-free if it is issued by an entity with no default risk, and the specific instrument to derive the risk-free rate will vary depending on the period over which the return is to be guaranteed (Damodaran, 2008). Risk is usually defined in terms of variance of actual returns around the expected return and employs measures of market factors applied to different models to determine adjusted discount rates. The cost of equity should be higher for a riskier investment and lower for a safer investment (Damodaran, 2008).

To standardize the employment of discount rates in NPV and EAC calculations across all federal agencies, the Office of Management and Budget (OMB) annually provides discount rates that should be used by government agencies. These rates are published in OMB Circular A-94 and provide rates per an investment period for a calendar-year budget. The rates are based on economic assumptions for the next year’s budget. Two separate discount rates are provided, the nominal rate and the real rate. Nominal rates are used for discounting nominal flows often encountered in purchase/lease analysis. Real rates are used for discounting constant dollar cash flows, as is often required in cost-effectiveness analysis. Analysis of program terms that do not fall within the six defined periods may use linear interpolation to determine the appropriate rate.

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III. RESEARCH METHODS

This thesis aims to provide a method to categorize, account for, and maintain assets within the Marine Corps IT portfolio. The scope of the portfolio is broad and includes garrison, tactical, and robust systems of systems. These assets are represented in many legacy stand-alone systems, meant in many cases to provide a specific type of support and management. As it becomes increasingly necessary to field a unified information enterprise, the requirement to assess the current state of the enterprise is critical to its managements.

Numerous sources of inventory information were examined during this research. As the DON-wide system for accounting for IT assets, the DITPR-DON was examined for use in this research. However, GAO reports in 2012 and 2014 noted that this system does not fully account for IT assets within the DON and Marine Corps (Cha, 2014). The GAO reports site that certain data fields in the data set were incomplete, incorrect or duplicative and that extensive manual clean-up efforts were still on-going. PBIS-IT, a DON wide system for tracking annual IT purchases, was also examined as a data source. It was found that reports from this system did not contain the desired level of detail and did not provide enough historic data to be useful. The DITPR-DON and PBIS-IT systems provide information concerning DON IT assets, however, these systems provide data that are too general for use in this study. The MDR, a database used to compile data from numerous Marine Corps stand-alone systems daily, provides several layers of data that come from a multitude of sources. It appeared that this central data-collection point would provide the greatest amount of data specific to the Marine Corps. Thus, the MDR was chosen for analysis since it is populated by numerous other sources automatically, and should provide the most current and accurate data for analysis.

With data collected from the MDR, this research will provide a systematic approach to categorizing and evaluating the available data. The method of developing categories is based on current budgeting publications and guidance towards providing a single reporting standard through the various stages and levels of the PPB&E process. The evaluation of the current status of the hardware inventory uses available data and

organizes it in a fashion to provide pertinent and usable information. The intent is to provide decision makers with a framework to approach technology refreshment and asset management by applying a methodology to currently available data.

A. CLASSIFICATION OF ASSETS

The scope of configuration management affects how the IT infrastructure can be assessed, tracked, and managed. The scope can be divided into areas with their own information requirements and approach to implementation. Examples of these areas are workstations, data communications, file, print and application services, central processing, databases, IT systems, and telephones services (OGC, 2005). When developing an identification system, decisions must be made concerning the scope and level of detail of the information to be recorded. In examining the Marine Corps enterprise, sub-dividing components of the enterprise that align with budgeting and programming requirements is beneficial from both an asset management and financial management perspective.

Examining the Marine Corps IT enterprise requires categorizing assets by examining both asset identity and programming requirements. During the DON Information Technology and National Security System (IT/NSS) fiscal year 2013 annual budget review, significant progress was noted in the reduction of the DON IT/NSS total number of individual networks and common networking infrastructure, such as data centers and software applications since 2006, to maintain this progress and gain better insight into how the DON is planning and executing its IT resources. The DON CIO modified budget line item guidance was provided for the FY14 programming and budgeting information systems-IT submission (Halverson, 2012). This guidance separated IT investments into the three basic categories of hardware, software, and services. These categories are identified by Nash (2009) as the categories into which most direct IT costs are made.

Further guidance was provided within the memorandum as to what assets should be placed in each of these three groups. The following list is not an exhaustive accounting

of what should be included in each category; however, it provides adequate guidance for categorizing items not specifically mentioned.

- Hardware:
  - **Desktop Hardware:** This category consists of IT desktop hardware purchases, including:
    - Desktop
    - Laptop
    - Thin Client
    - Tablet
    - Workstations
    - Internal Computer Components
  - **Communications/Network Equipment:** This category consists of all IT communications equipment, including:
    - Network Equipment and Infrastructure
    - Data Processing and Switching
    - Packet switching equipment
    - Routers/firewalls
    - Radio Equipment
    - Wireless Network Equipment
    - Satellite Communications
    - Video teleconference/Audio and Visual Equipment
    - Terrestrial Carrier Equipment
    - Telephonic Equipment including Cellular
    - Fiber Optics and other Communications Networking Equipment
    - Information Assurance Equipment
    - Wide Area Network Services/Equipment
  - **Server Hardware:** This category consists of server IT hardware purchases, including:
    - Network/Enterprise Storage
  - **Peripheral Hardware:** This Category consists of all peripheral IT hardware, including:

- Printers copiers, scanners, multi-function devices
- LCDs
- Keyboards, monitors, speakers
- Bar code scanners
- Smart boards

- **All other Costs-Commercially Acquired:** This category consists only of other commercial costs not better identified elsewhere, including:
  - Diskettes, CD-ROM
  - Print cartridges
  - Printer paper
  - Consumables/other

Currently, TAMCNs are assigned to systems or groups of systems with similar capabilities to provide accounting for systems that fit into the “desktop hardware,” “communication/network equipment,” and “server hardware” categories. The current list of TAMCNs does not provide a detailed accounting of assets that fall within the “all other costs” and “peripheral hardware” categories. These items are typically purchased at the unit level and are not tracked with the desired degree of fidelity in the systems that provide data to the MDR.

Additional guidance is provided within the memorandum for detailed categorization of both the software and services categories. Significant costs are incurred in developing, procuring, and maintaining software. Currently, these costs are not tracked within the MDR. The cost of services to support the infrastructure also requires significant cost. The MDR currently maintains a list of physical items and does not track software or services under any specific TAMCN. This research is thus limited to the assets currently reported in the MDR. Research into software and services costs and analysis requires additional, in depth research that is not covered in this study.

The Marine Corps IT inventory spans a broad range of systems and capabilities. For example, currently, the communications and electronics commodity list contains over 700 active TAMCNs. These 700 TAMCNs consist of not only individual components, such as laptops, desktops and servers, but also designated systems of systems. These

systems of systems are a collection of task-oriented systems that pool their resources and capabilities. These systems often have computers, routers, servers, and peripheral devices that comprise the system. Such embedded IT is difficult to account for given that all these items are tracked under a single TAMCN. This thesis focuses on the inventory of hardware assets currently tracked within the MDR. Systems are categorized based on their functions. Individual components that comprise these systems are included in the procurement cost of the system and are not accounted for separately. Laptops, desktops, and servers that are accounted for as stand-alone devices and replaceable through the MCHS catalog are used to determine appropriate refreshment cycles for those assets. The methodology employed in this study can be applied across various systems, as well as stand-alone devices and provides a foundation for future evaluation of IT hardware assets within the Marine Corps IT inventory.

To determine the baseline value of hardware assets in the inventory, it was necessary to choose between procurement cost or depreciated value of the assets. Although the ITIL recommends both values be maintained on systems within the CMDB, the date of initial procurement of systems was not available within the MDR. For this reason, the procurement cost of each asset was chosen for use instead. The TAMCNs are categorized based on the above-defined categories. The Enterprise Asset Posture Report is used to identify the enterprise asset posture, which includes the sum of all assets wholesale and retail on-hand, government furnished property, and pending ship/shipped for both wholesale and retail. The total number of on-hand assets within each TAMCN and their corresponding NSNs is provided. The procurement value for the individual NSNs is summarized to determine the overall procurement value of assets.

B. TECHNOLOGY REFRESHMENT

The technology refreshment cycles of systems can be determined in a variety of ways. Many organizations determine whether to purchase a new piece of hardware based on the anticipated ROI of that hardware. This method usually determines whether a piece of hardware purchased will provide returns over the period it is used. ROI requires an intended life cycle of a system be known prior to the acquisition of the system. This

method is useful in determining if a system should be acquired, but does not provide a means of anticipating what the life cycle of a system should be. Another approach to determining technology refreshment cycles is to analyze the historic operation and support costs for a system and then use them to determine the appropriate life span of a system. An equivalent annual cost is like an annuity that has the same life and present value as the underlying cost stream, which allows uneven cash flows to be converted into smooth, regular cash flows that can be compared more easily (Mahvi & Zarfaty, 2009). Managers are then able to determine the most cost efficient life of the system and plan its technology refresh to coincide with that timeline (Mahvi & Zarfaty, 2009). This method provides means maximizing ROI by minimizing the total cost of ownership of a system and maximizes the investment returns over an anticipated life cycle.

The MCHS catalog provides a multiple hardware options for laptop computers, desktop computers, and servers. Systems currently available in the MCHS catalog under the corresponding TAMCN represented in their baseline configurations are shown in Tables 1–3 in year 2015 dollars:

Table 1. Laptops

TAMCN	Description	Price
A91002B	General Purpose Laptop	$1,035.00
A90237G	High Performance Laptop	$2,250.44
A90197G	Tablet	$1465.68
A90207G	Rugged Convertible Tablet	$2609.25
A25467G	Rugged Laptop	$3,251.85

Table 2. Desktops

TAMCN	Description	Price
A93002B	General Purpose Desktop	$1,236.90
A90627G	High Performance Desktop	$2,161.32

Table 3. Servers

TAMCN	Description	Price
A95102B	Blade Server	$37,660.20
A95002B	Departmental Server	$8,004.15
A90257G	Deployable 1U Server	$6,495.48
A25487G	Entry Level 2U	$6,457.50

Each system provides varying levels of performance, and all systems have a 4-year return to depot maintenance warranty.

Determining the EAC requires the historic operation and support cost for similar information systems per year. Various Navy and Marine Corps sources were examined to determine the required costs. Unfortunately, data for the TAMCNs being examined in this study were not available in adequate detail and consistency to be useful. Most complete operation, support, and maintenance data were available on larger systems of systems that have been designated as mission essential equipment and are tracked and reported with greater rigor.

To obtain an operation and support cost estimate, a number of techniques can be employed. The *2014 DOD Operation and Support Cost Estimating Guide* provides a review of policies and procedures focused on the preparation, documentation, and presentation of system operation and support cost estimates, as well as identifies a standard set of categories of operational and support cost elements. Analysts accomplish cost estimating using a combination of three approaches.

- Parametric Method—This method uses regression or other statistical methods to develop cost estimating relationships. Two subtypes of this method are the following.
- Analogy Method—This method is used to estimate a cost based on historical data for analogous systems.
- Engineering Estimate—This method uses discrete estimates of labor and material costs for maintenance and other support functions. The system being costed normally is broken down into lower-level components that are each costed separately.

This analysis employs the analogy method to predict the relevant costs.

To estimate operations and support costs for laptop and desktop information systems, data from a study conducted by Morey and Nambiar (2009) is used. The gathered information represents 106 different companies from 15 different industries. The data collected reflected costs of help desk support, issue resolution, maintenance, and out-of-warranty support costs. Help desk support, issue resolution, and maintenance costs are annotated as operation and support cost in the Tables 4–5. The age distribution of laptops and desktops within the 106 different companies was also collected. These costs, when adjusted for inflation from 2009 to 2015 dollars utilizing the Bureau of Labor Statistics Consumer Price Index, are shown in Tables 4 and 5.

Table 4. Estimated Laptop Operating Cost

Cost	**1 year**	**2 year**	**3 year**	**4 year**	**5 year**
Operation and Support Cost	$783.37	$902.00	$1,042.66	$1,242.88	$1,496.71
Out of Warranty Maintenance Cost	$0	$0	$0	$0	$380.74

Table 5. Estimated Desktop Operating Cost

Cost	**1 year**	**2 year**	**3 year**	**4 year**	**5 year**
Operation and Support Cost	$473.74	$547.04	$631.29	$752.73	$829.77
Out of Warranty Maintenance cost	$0	$0	$0	$0	$131.29

The data collected by Morey and Nambiar (2009) did not provide information on the historic annual cost of operating and supporting servers. A study conducted by Noelle (2010) gathered average server costs per server information from 161 midsize businesses. They provided an average annual cost, per year, for servers deployed for up to a seven-year period. These costs are adjusted for inflation from 2010 to 2015 dollars, as shown in Table 6.

Table 6. Estimated Annual Server Operating Cost

Cost Component	1 year	2 year	3 year	4 year	5 year	6 year	7 year
Power/Cooling	$212.59	$212.59	$212.59	$212.59	$212.70	$212.70	$212.70
Maintenance	252.00	252.00	252.00	252.00	$552.56	$552.56	$552.56
Management/ Support	$645.86	$645.86	$645.86	$645.86	$889.85	$889.85	$889.85
Outage/Downtime Cost	$968.79	$968.79	$968.79	$968.79	$1406.54	$1406.54	$1406.54

With the average annual cost of operation and support and a known acquisition cost, EAC analysis of each of the systems can be performed to determine the most cost effective life cycle of each of the systems. Once optimal refreshment timelines are determined, forecast of potential hardware purchase costs can be made based on the current inventory. The study conducted by Morey and Nambiar (2009) included information on average computer age. The study determined that most organizations reported having laptop and desktop computers maintained roughly 30% percent of their inventory within the three to four years of age. To provide a comparison, costs for refreshing 25% and 20% of the inventory are also examined to determine what rate corresponds best with the suggested refreshment cycle determined by the EAC analysis. By applying this percentage to the previously determined inventory of laptops, desktops, and servers, an approximate number of systems to be refreshed can be determined.

OMB provides discount rates to be used by federal agencies when conducting lease/purchasing analysis of products. These rates provided for 2015 are 1.7% for a 3-year investment and 2.2 % for a 5-year investment. The current refresh cycle is intended to be four years to coincide with the current warranty expiration. Linear interpolation is used to determine a discount rate of 1.95% for four years. This discount rate is used to determine the appropriate discount factors during the analysis.

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IV. ANALYSIS

The data analyzed in this research represent IT hardware assets currently accounted for in the MDR. The MDR is a database populated daily by 31 separate source systems to provide a single source of data to provide inventory and logistics information. The EAPR provides a detailed asset accountability report for systems in the MDR. The EAPR utilized in this analysis was acquired March 11, 2015. The inventory analysis in the next section provides a baseline for the allocation of hardware assets and categorizes them by their system characteristics and functions according to the categories outlined in the previous chapter.

The communications and networking equipment category accounted for the greatest asset value. Assets categorized within this category were divided into subcategories to aid in the understanding of the types of assets accounted for. The subcategories utilized within this research are data processing and switching, information-assurance equipment, satellite communications equipment, telephone-sets, wide-area network equipment, radio-sets, network infrastructure, fiber-optics and other-network equipment and video-teleconference and audio and visual equipment. These subcategories align with items included in the broader communications and networking equipment category defined in Chapter III. In many cases, assets could be placed in more than one subcategory, particularly in the case of systems procured for tactical use. In these cases, the asset was analyzed based on its intended purpose and sub-components then placed in the subcategory that best defined them.

A. INVENTORY OF HARDWARE

The data contained in the MDR were examined to determine the total number of assets. The total procurement value for assets categorized from the EAPR is shown in Figure 2. All assets within the inventory were first identified by their unique TAMCNs.

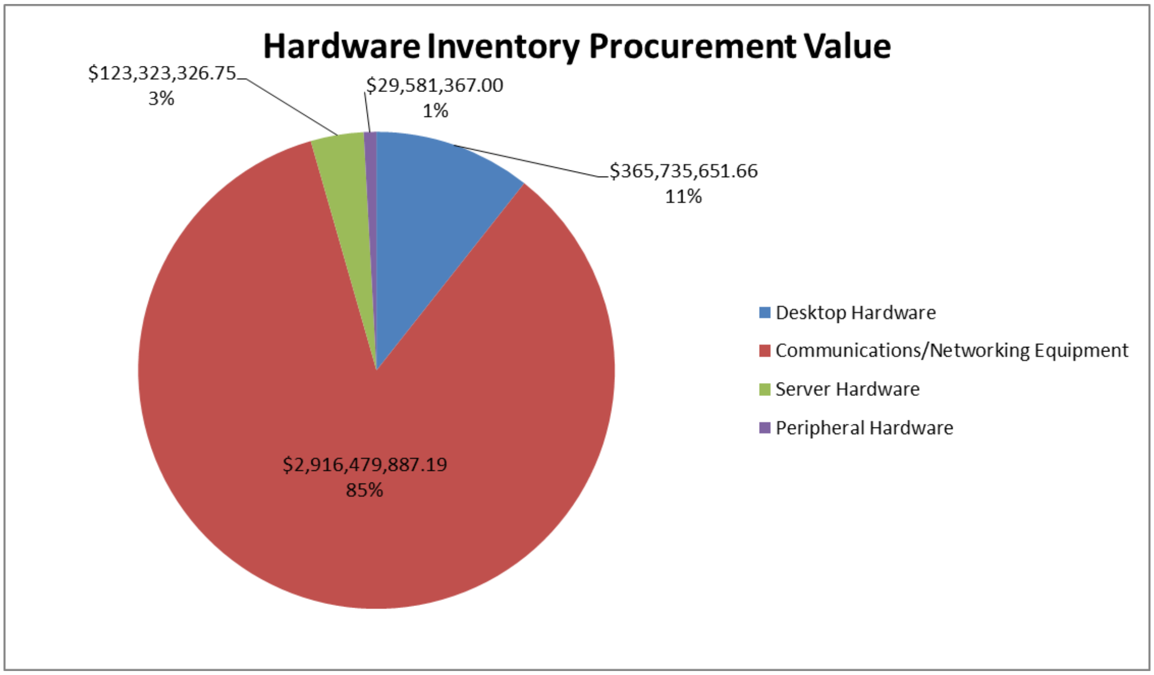


Figure 2. Hardware Asset Inventory

System descriptions for each TAMCN were used to place the system in the category and subcategory that best defined the capability and function of the system supported. Each TAMCN could be comprised of systems from different manufacturers or system versions, which often had varying procurement costs. These costs are accounted for by unique NSN. The sum of the quantity of each NSN was multiplied by the procurement cost for each NSN under a TAMCN. The sum of the assets in each NSN and their total procurement cost was used to determine the overall value and quantity of systems under a TAMCN.

The majority of assets were categorized into the communications/networking equipment category. This category identified a broad scope of assets that provide varying types of communications capabilities and was mostly comprised of systems of systems. Their overall procurement costs were significantly higher due to the specific requirements, equipment, and capabilities of the systems. Desktop hardware, server hardware, and peripheral hardware account for 15% of the overall procurement value of the inventory. These categories identified individual assets that although higher in

individual quantity, cost significantly less than the systems in the communications/networking equipment category.

1. Communications and Networking Equipment

The assets in this category accounted for the preponderance of assets within the inventory. This is likely due to the large collection of complex systems of systems that carry a significantly higher procurement cost.

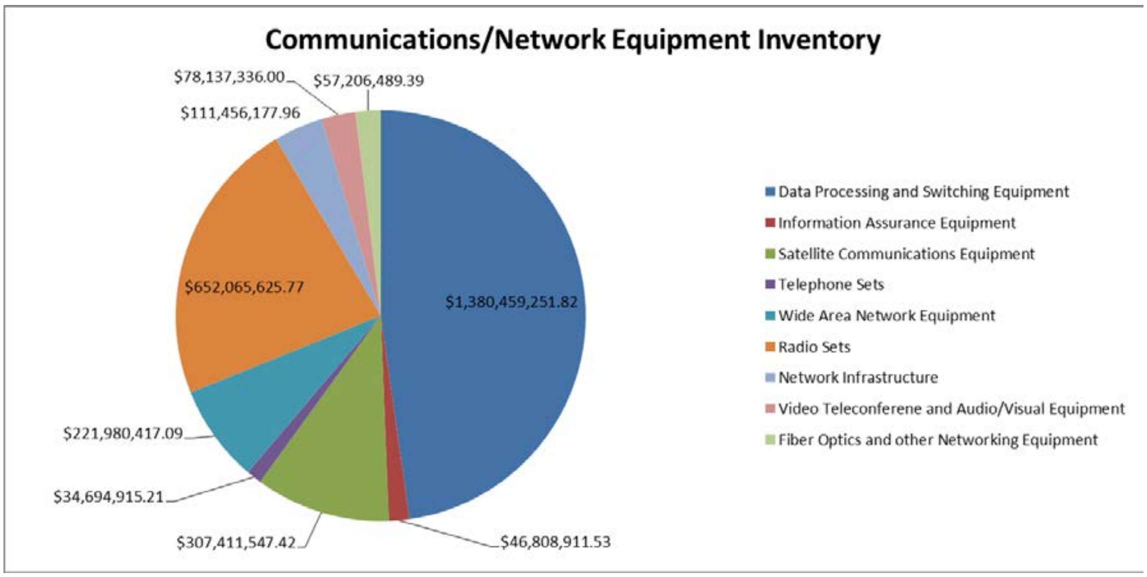


Figure 3. Communications and Network Equipment

This category of assets represents the majority of costs within the inventory. The data processing and switching equipment subcategory is comprised primarily of systems designed to collect, analyze, and distribute data. These systems include processers, routers, switches, and servers necessary to provide a networking capability. The components of these systems are not accounted for individually, so the overall procurement value of the systems was used in calculating the overall value of the subcategory. An example can be found in the Distributed Data Distribution system, A25387, which is comprised of a local area network (LAN) server, LAN router, five Ethernet switches, three media converters, four loop encryption devices, and the required tool kits. The procurement cost of a Distributed Data System is $99,000 and the inventory

accounted for 12 of them. Systems in this subcategory comprise 10,881 of the total 78,980 assets in the category, but due to the high per-system procurement cost, account for 47% of the overall procurement value of systems in this category.

The information-assurance equipment subcategory is comprised of devices that encrypt and decrypt data and systems designed to provide for the security of information and data within systems. These assets consist of individual components and systems of systems whose primary purpose is to provide information assurance functions. The 5,475 assets in this subcategory account for only 2% of the overall procurement value for the category.

The satellite communications equipment subcategory has assets and systems that were identified in the inventory as having a primary function of providing satellite communications capability. The 3,947 assets in this subcategory account for 10% of the overall procurement value in this category. The telephone-sets subcategory is comprised of phones, switchboards, and call-management devices. Noticeably absent from accounting in the MDR are cellular-telephone assets, which would be categorized in this subcategory. The 3,947 assets in this subcategory comprise only 1% of the overall category procurement value.

Assets categorized in the radio-sets subcategory consist of voice and data communications, as well as systems designed to provide radio-frequency-emitter detection and jamming. This subcategory is comprised of 13,007 individual assets that represent 22% of the overall procurement value of this category.

The wide-area networking equipment subcategory is comprised of those assets that primarily support the management of networks and facilitate the linking together of local networks. This subcategory identifies 3,671 assets and comprises 7% of the overall procurement value in this category. The network infrastructure subcategory is comprised of assets that facilitate the transmission of data, such as antennas and dishes, and their mounting components. Many of the assets categorized in other subcategories, such as radio sets and communications, and networking equipment likely include antennas and

other components that allow for the transmission of data. The 7,386 assets accounted for in this subcategory comprise only 3% of the overall procurement value for the category.

Similar to the network-infrastructure subcategory, the fiber-optics and other-networking-equipment subcategory is comprised of assets that facilitate the transmission of data between systems. It is comprised of reels of fiber optic and telephone cables used to establish a physical connection between systems. This subcategory comprises 19,866 individual assets, and represents only 2% of the overall procurement value of the category.

The video-teleconferencing and audio and visual equipment subcategory contains assets that provide still and video images, as well as systems that monitor the collected data. These assets perform force protection functions, aid in the collection of materials for public affairs, and support intelligence exploitation of video and still images. This category comprised 3,218 assets and account for 3% of the overall procurement value of this category.

2. Desktop Hardware

Desktop hardware analyzed for this thesis includes laptops, desktops, and workstations.

a. Laptops

The inventory of laptop computers is tracked with 14 different TAMCNs, as shown in Figure 4.

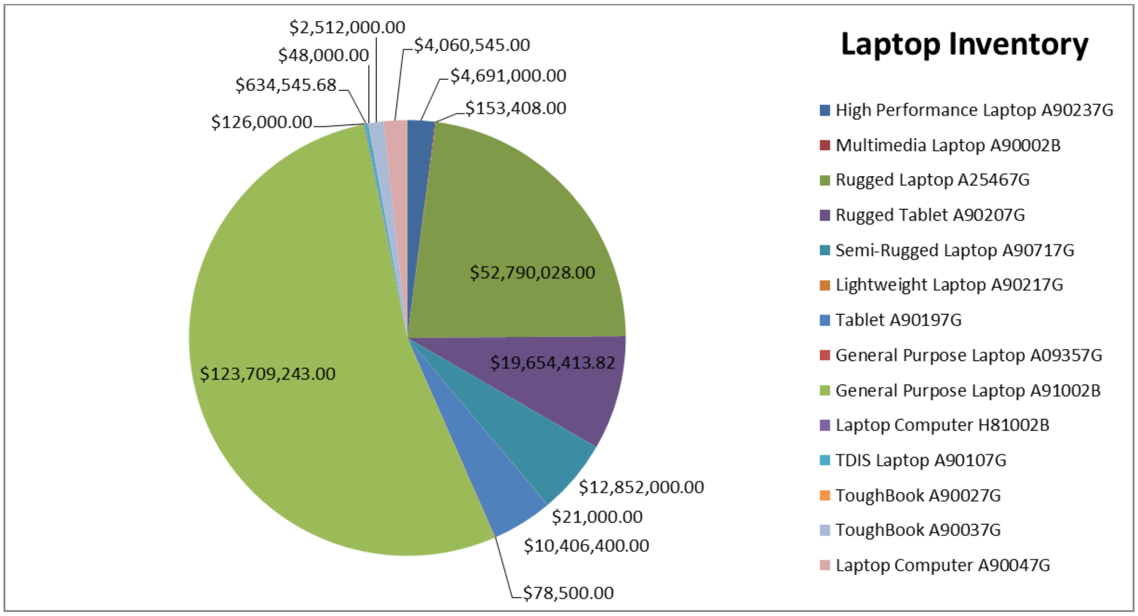


Figure 4. Laptop Composition

These TAMCNs are composed of 38 separate NSNs. Within the inventory, 73,315 assets are currently tracked as laptop computers. General-purpose laptops are intended to provide functionality for everyday computing. High performance and multimedia laptops are intended to provide parallel processing when running multi-threaded applications or multiple applications simultaneously. Tablets are small mobile computers primarily designed for web browsing and emailing. Ruggedized variations of the systems previously mentioned are also distinguished. Systems under the A90107, A90027, 90037 and 90047 TAMCN are intended for use with specific applications that support larger systems but are tracked and procured as individual assets; these systems account for 1% of laptop procurement value.

b. Desktops and Workstations

The inventory of desktop computers and workstations is tracked with 17 different TAMCNs and 51 separate NSNs, as demonstrated in Figure 5.

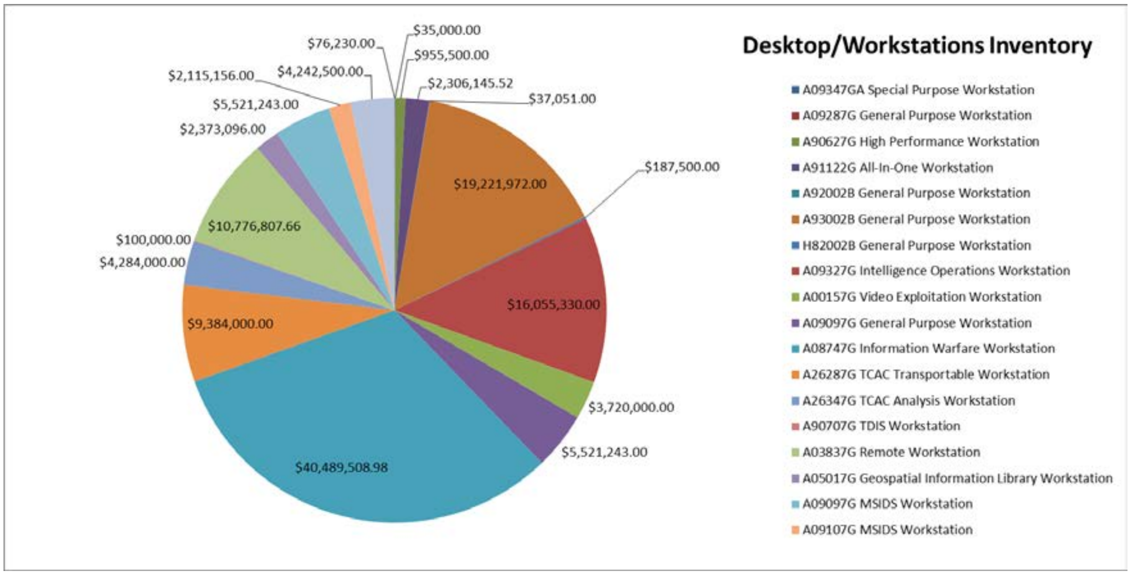


Figure 5. Desktop/Workstation Composition

The term workstation is used for stand-alone desktop computer systems within the inventory. Stand-alone workstations account for 17,754 assets. General purpose workstations are intended to meet the requirements for everyday computing needs. Special-purpose, high-performance, and all-in-one workstations are robust graphics workstations that help to optimize intensive 2D/3D applications; they provide fast processing speeds and can multi-task through multiple applications. Workstations designed to support specific applications are procured for those applications. These systems are tracked as stand-alone workstations because they require the attachment of peripheral devices to perform their function. These workstations account for 7,535 of the 17,754 systems and represent 44% of the overall procurement value of workstations.

3. Server Hardware

Similar to the desktop hardware category, the server hardware category is comprised of servers and memory units available both commercially and procurable through the MCHS catalog, and systems developed to function with specific applications for military and government use. See Figure 6.

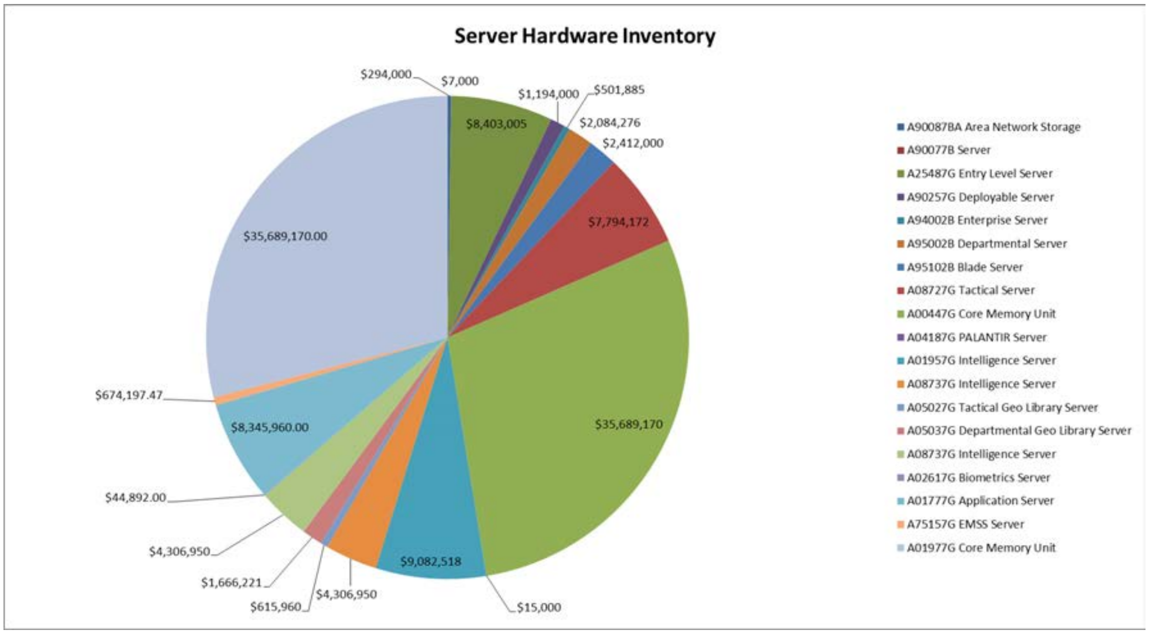


Figure 6. Server Composition

The 19 TAMCNs that account for stand-alone servers are comprised of 56 different NSNs. As with systems in the desktop hardware category, systems for specific government and military uses, such as geospatial library servers and intelligence servers have a greater procurement cost due to the unique capabilities and configurations required of those systems. Of the 3,948 assets accounted as stand-alone servers, 1,589 systems are designed for a specific tactical purpose, which accounts for 58% of the total recorded stand-alone server cost. Due to the unique design and function requirements of these systems, their procurement cost is significantly more than servers acquired through the MCHS program.

Those servers that are procurable through the MCHS program provide a wide range of services. Blade servers (A95102) are the most complex and costly of the MCHS servers offered, which allow for the support of multiple virtual servers. Each blade within the server is treated as a removable separate server. Departmental servers (A95002) are designed to support 100 to 4,000 users with medium data warehousing capability. Deployable 1U and 2U servers (A25487 & A90257) are designed to support between 30 and 400 users and provide file-sharing and network-printing functions.

4. Peripheral Hardware

Items within the peripheral hardware category are those devices that connect to computing systems and interact with that system by providing data input or facilitating output from the system. See Figure 7.

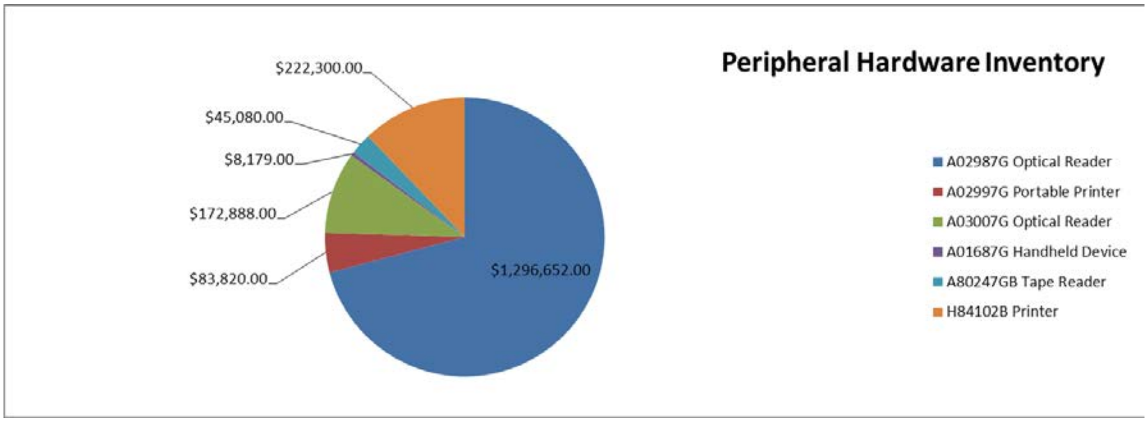


Figure 7. Peripheral Hardware Composition

Within the MDR, 2,236 items were identified as peripheral hardware. The items represent an overall procurement value of approximately $1.8 million. Items that fall within this category do not appear to be accounted for with the desired degree of detail. Analysis of printer purchase data for the Marine Corps in fiscal year 2013 indicates that in that year alone, over $2.7 million dollars were spent purchasing printer devices (USMC IT Strategy Group, 2014). The reported single-year spending on printing devices alone well exceeds the total procurement value for all hardware identified as peripheral hardware within the MDR.

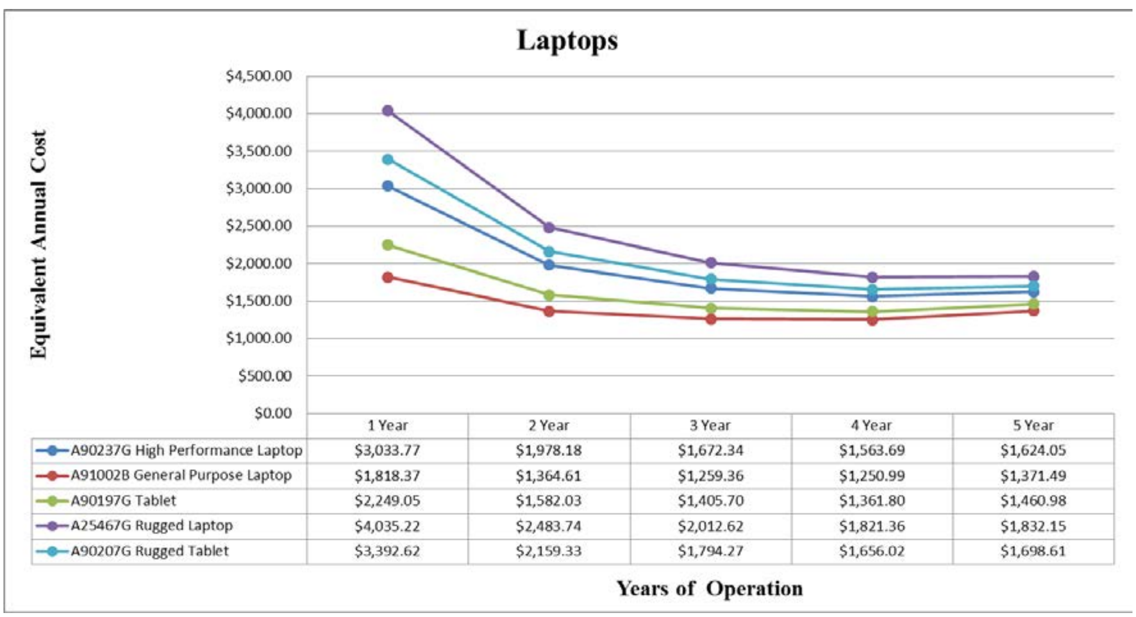
Currently, laptops and desktops procured through the MCHS program have customization options that include monitors, keyboards, and optical mouse devices can be added to new system procurement orders. The MDR only tracks the baseline acquisition cost of systems and does not account for the purchase of these additional items.

B. TECHNOLOGY REFRESHMENT

This section provides an analysis of IT assets that can be refreshed through the MCHS catalog based on parameters outlined in Chapter III. The EAC is a means of discount cash flow investment that converts cash flows into a series of uniform amounts, as computed for systems that can be procured through the MCHS catalog. The figures in the following sections show the yearly sum of associated costs for systems, converted to an EAC value. These values were then summed and depicted in the following figures, which provides both a graphic representation and total EAC value for each year of system operation. A measure of what can be expected to be spent, as an annual average, over the life of an asset is provided. When the value begins to increase, the cost to operate a system annually will continue to increase in subsequent years and the system should be replaced.

1. Laptops

Figure 8 shows the equivalent cost decreases until the 4th year of operation and then begins to rise.



	1 Year	2 Year	3 Year	4 Year	5 Year
A90237G High Performance Laptop	$3,033.77	$1,978.18	$1,672.34	$1,563.69	$1,624.05
A91002B General Purpose Laptop	$1,818.37	$1,364.61	$1,259.36	$1,250.99	$1,371.49
A90197G Tablet	$2,249.05	$1,582.03	$1,405.70	$1,361.80	$1,460.98
A25467G Rugged Laptop	$4,035.22	$2,483.74	$2,012.62	$1,821.36	$1,832.15
A90207G Rugged Tablet	$3,392.62	$2,159.33	$1,794.27	$1,656.02	$1,698.61

Figure 8. Laptop Computer EAC Analysis and Sensitivity Analysis as a Function of Different Product Life cycles (after Morey and Nambiar, 2009)

This analysis indicates that the suggested refresh cycle for systems procured is four years. If the systems are used beyond the 4-year period, the cost to own and operate the system begins to increase, which indicates that by delaying refreshment of laptop computers to year 5, a higher equivalent annual cost for the laptop results. This refreshment timeline is consistent with current manufacturers maintenance warranty offered for systems procured through the MCHS catalog. By identifying the optimal refreshment timeline for the systems, a forecast of anticipated future costs can be derived.

Updates to the MCHS catalog often come with updated TAMCNs for new system types, such as tablets, and removal of TAMCNs for legacy systems no longer offered for procurement, such as all-in-one workstations. To align the current laptop inventory better with items currently offered in the MCHS catalog, TAMCNs that are no longer offered in the MCHS catalog were added to the current asset counts of TAMCNs offered in the catalog. These legacy systems account for less than 5% of the laptops identified in the inventory analysis. The basic descriptions of the laptop computers facilitate alignment with TAMCNs currently offered.

The asset count and values in Table 7 represent the current inventory and the total number of laptops within each TAMCN.

Table 7. Laptops Computers Refresh Cost Varied by Inventory Percentage

Laptop Computers		Asset Count	Baseline Item Cost	20% Refresh	25% Refresh	30% Refresh
A90237G	High Performance Laptop	1,765	$2,250.44	$794,405.32	$993,006.65	$1,191,607.98
A25467G	Rugged Laptop	15,605	$3,251.85	$10,149,023.85	$12,686,279.81	$15,223,535.78
A90207G	Rugged Tablet	5,315	$2,609.25	$2,773,632.75	$3,467,040.94	$4,160,449.13
A90197G	Tablet	4,342	$1,465.68	$1,272,796.51	$1,590,995.64	$1,909,194.77
A91002B	General Purpose Laptop	45,167	$1,035.00	$9,349,569.00	$11,686,961.25	$14,024,353.50
	Total:	72,194		$24,339,427.43	$30,424,284.29	$36,509,141.15

Table 7 depicts the cost to refresh varying percentages of the inventory every year. The costs are shown in fiscal year 2015 dollars. The total cost to refresh laptop computers reflects the current cost of replacement systems in fiscal year 2015 dollars. A refresh of 30% of the identified inventory would cost over $36.5 million annually. If 25%

of the systems are refreshed annually, the cost based on the inventory would be 30.4 million, and if 20% of the inventory was refreshed, the annual cost would be 24.3 million.. Analysis of laptop purchases in fiscal year 2013, done by the USMC Program Assessment and Evaluation Branch, accounted for over $25 million in laptop purchases. The cost to refresh 20% of the inventory a year is close to the laptop purchases in fiscal year 2013. To align better with the suggested refresh cycle of four years, refreshing 25% of the inventory should be considered for refreshment annually so that the entire inventory is replaced every four years.

2. Desktops and Workstations

Figure 9 depicts the EAC analysis of baseline desktop workstations with varying product life cycles that can be procured through the MCHS catalog**.**

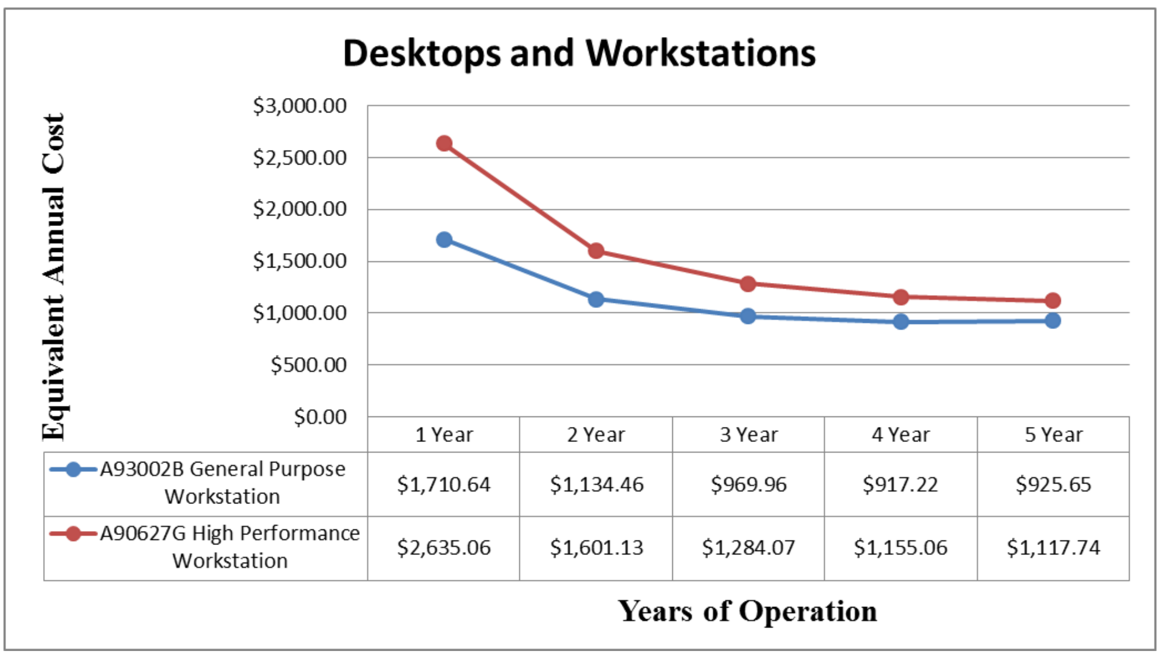


Figure 9. Desktop/Workstation EAC Analysis and Sensitivity Analysis as a Function of Different Product Life cycles (after Morey and Nambiar, 2009)

As with all the laptop systems, the general purpose workstation begins to incur a greater cost to own and operate beyond the 4th year of system employment. Although it

only shows a minimal increase in the 5th year of operation, this cost will continue to increase the longer the system is operated. The cost to operate, support, and maintain the system out-of-warranty, will also continue to increase in subsequent years. The equivalent cost to operate the high performance workstation systems continues to decrease into the fifth year, which indicates that it would be beneficial to operate this system into a 5th year and potentially longer. No data were available for operation and support costs and out-of-warranty maintenance beyond the 5th year.

Similar to the situation encountered with laptop computers, several legacy systems are accounted for within the MDR that are no longer refreshable TAMCNs through the MCHS catalog and no longer have a corresponding TAMCN listed within the available MCHS workstations. These legacy systems account for 2% of the workstations that were at one time part of the MCHS catalog. As with laptop computers, the descriptions provided of these legacy systems allow them to be added to the quantities of systems currently available in the catalog.

Table 8 shows the total number and cost of refreshing varying numbers of desktop and workstation systems accounted for in the MDR.

Table 8. Desktop/Workstation Computers Refresh Cost Varied by Inventory Percentage

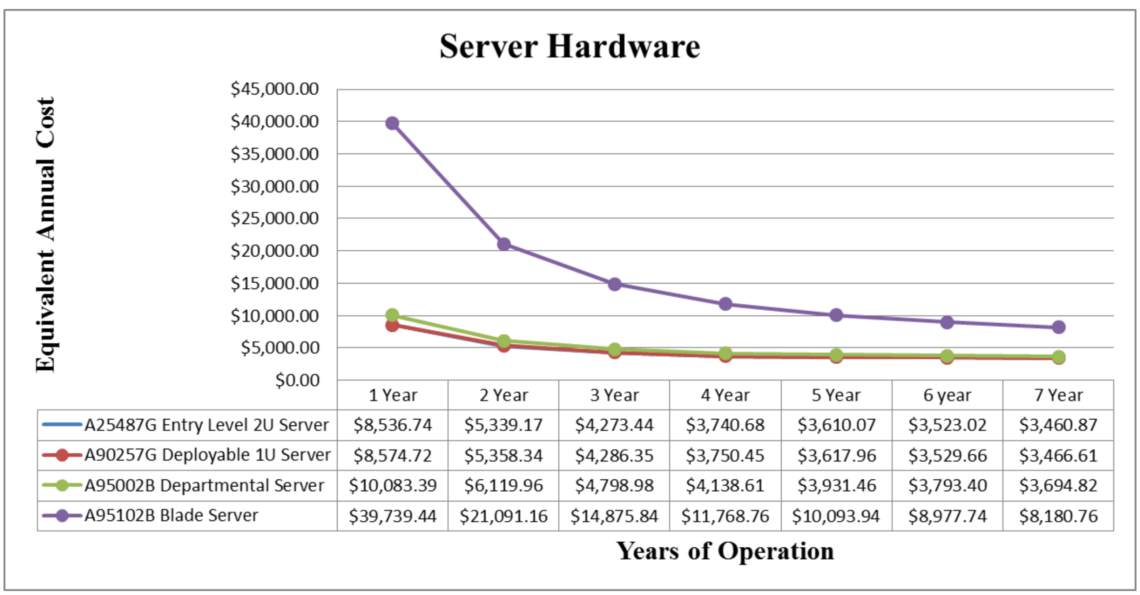
Desktop/Workstation Assets		**Asset Count**	**Baseline Item Cost**	**20% Refresh**	**25% Refresh**	**30% Refresh**
A90627G	High Performance Workstation	408	$2,161.32	$176,363.71	$220,454.64	$264,545.57
A93002B	General Purpose Workstation	9,252	$1,236.90	$2,288,759.76	$2,860,949.70	$3,433,139.64
Total:		9,660		$2,465,123.47	$3,081,404.34	$3,697,685.21

The total cost reflects the cost to refresh the systems in fiscal year 2015 dollars. According to the EAC analysis, general-purpose workstations should be refreshed every four years, which coincides with the current warranty offered under the MCHS program. Based on the EAC analysis of currently available high performance workstations, their refresh can be extended beyond four years without increasing the equivalent annual cost of the system. The annual refreshment cost to refresh 30% of general purpose

workstations is $3.7 million in fiscal year 2015 dollars. The cost to refresh high performance workstations is $291,000.00, even though the per-system cost is greater, the number of systems accounted for only comprise 4% of the overall inventory of desktops/workstations. By reducing the percentage of the inventory to be refreshed to 25%, general-purpose workstations would cost $2.9 million annually and $220,000.00 annually for high-performance workstations. A reduction to 20% of the inventory would reflect costs of $2.3 million for general-purpose workstations and $176,000.00 for high performance workstations. Adjusting the percentage of systems refreshed each year could aid in more closely aligning the refreshment of systems with life cycle indicated by the EAC analysis. For general-purpose workstations, 25% should be considered because it will result in the replacement of the entire inventory on a 4-year cycle. For high-performance workstations, 20% should be considered, as it will allow for the inventory to be completely refreshed every five years.

3. Server Hardware

The EAC of server systems acquired as a function of different product life cycles is depicted in Figure 10.



	1 Year	2 Year	3 Year	4 Year	5 Year	6 year	7 Year
A25487G Entry Level 2U Server	$8,536.74	$5,339.17	$4,273.44	$3,740.68	$3,610.07	$3,523.02	$3,460.87
A90257G Deployable 1U Server	$8,574.72	$5,358.34	$4,286.35	$3,750.45	$3,617.96	$3,529.66	$3,466.61
A95002B Departmental Server	$10,083.39	$6,119.96	$4,798.98	$4,138.61	$3,931.46	$3,793.40	$3,694.82
A95102B Blade Server	$39,739.44	$21,091.16	$14,875.84	$11,768.76	$10,093.94	$8,977.74	$8,180.76

Figure 10. Server EAC Analysis and Sensitivity Analysis as a Function of Different Product Life cycles (after Noelle, 2010)

Unlike laptop and desktop/workstation computers, the equivalent cost of the servers continues to decline into the 7th year of operation to indicate that it would be financially beneficial to operate the servers as long as possible. The EAC analysis for A25487 and A90257 overlap due to their similar procurement costs. The manufacturer warranty of these systems is four years and coincides with their intended refresh cycles. Extensions of this warranty are available to extend the coverage for five years. The cost varies between $212.00 for A25487 and A90257 servers, and to $1,000.00 for A95102 servers. The analysis of the available data does not provide much insight into establishing an intended refreshment cycle that should be applied to these systems. The data suggest that the extension of server life beyond the intended refreshment cycle of four years is advisable based on the equivalent cost analysis.

Extending server life beyond four years can be seen as desirable based on the above analysis, however, refreshing servers on a 4- to 5-year cycle can be beneficial. As technology advances, the support provided by a single server increases, which allows for a reduction in the total number of servers, while still providing the required level of services and support (Trezza, 2015). This reduction in the number of assets can provide cost savings across a wide range of cost requirements, such as facilities, power, required support staff and security vulnerabilities (Perry, 2012).

Organizations tend to purchase their servers, and then following the initial investment, use a financially derived amortization period, often five to seven years. This time period provides for a predictable IT budget and servers are replaced based on a budget life and not their useful life. Extending server life cycles can create problems. Extending server life beyond five years can increase failure rates as much as 85% (Perry, 2012). Often, organizations refresh their software more frequently than their hardware, which creates a situation in which the hardware is not optimized for the newer software. Even though hardware requirements to support new software are not increasing as rapidly as in the past, it can still require frequent patching or can cause an organization to have to run multiple different versions of software at a time. This scenario can create more maintenance and management efforts that result in the increased cost to own and operate the server (Perry, 2012). Refreshing servers roughly every five years can maximize their

usefulness and minimize the consequences of operating aging servers. The refreshment of servers should not be considered as a one-to-one replacement. The greatest cost savings can be achieved by reducing the overall number of servers and purchasing only the number of new servers required to support identified requirements.

V. CONCLUSION

This thesis explored identifying sources for an accurate inventory of Marine Corps IT hardware assets, providing a monetary evaluation of those assets, and building a model for the technology refreshment cycle. Guidance provided by the DON-CIO and the USMC IT Strategy Group suggested asset categories to provide a better view of where the majority of IT costs are allocated. Once the assets were inventoried and categorized, an EAC model was applied to stand-alone systems in the desktop hardware category as a means of determining when they should be refreshed. Using operation, support, and maintenance costs from previous studies with the new system-procurement costs provided in the MCHS catalog, a prediction of future-year costs of procuring new systems was determined.

A. INVENTORY AND TECHNOLOGY REFRESHMENT

1. Inventory

The EAPR, an asset-level report written for the MDR, was analyzed to determine the total number of assets in the inventory and their procurement value. It was found that 85% of the overall procurement value of assets was within the communications and networking category. A large number of systems were categorized in the data processing and switch subcategory; these are comprised of devices employed together to provide a specific capability. Such broad categories for systems of systems limit the ability to account for the components within them such as routers, switches, servers, laptops, workstations, and peripheral devices. Thus, assets within the peripheral-hardware subcategory were underrepresented, which only included approximately 1% items individually accounted for within the MDR

2. Technology Refreshment

Figure 11 and Table 9 show the number and cost to replace laptop and desktop/workstation assets annually.

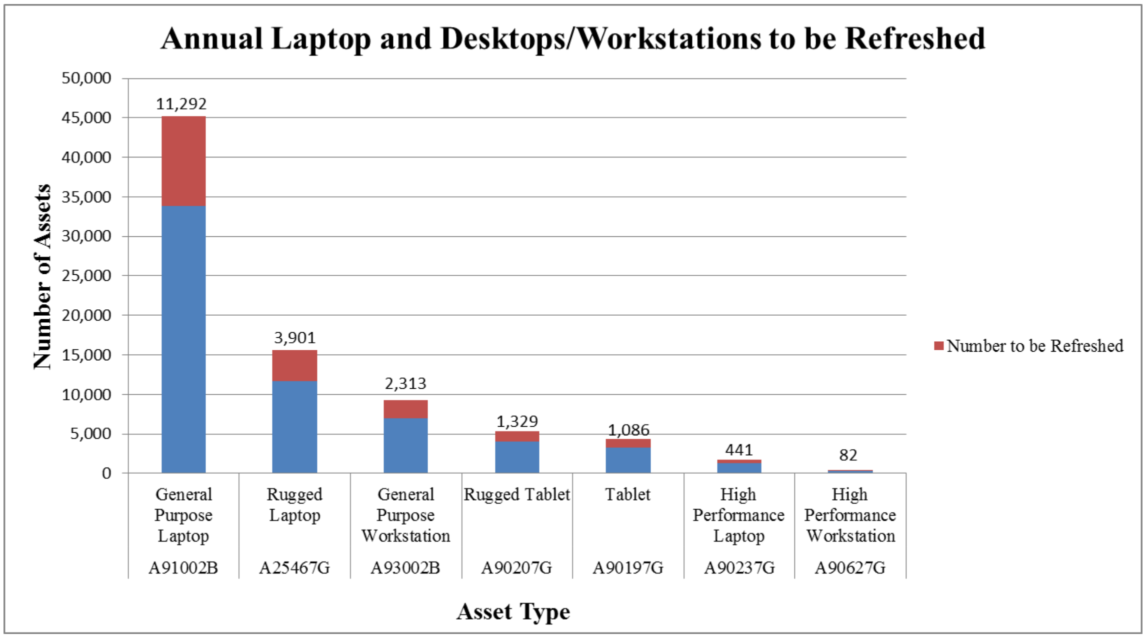


Figure 11. Depicts the Annual Number of Assets to be Refreshed Based on the EAC Analysis Provided in Chapter IV.

Table 9. Depicts the Annuals Cost to Refresh Assets

Laptop Computers		Assets to be Refreshed	New Asset Cost	Annual Cost
A91002B	General Purpose Laptop	11,292	$1,035.00	$11,686,961.25
A25467G	Rugged Laptop	3,901	$3,251.85	$12,686,279.81
A90207G	Rugged Tablet	1,329	$2,609.25	$3,467,040.94
A90197G	Tablet	1,086	$1,465.68	$1,590,995.64
A90237G	High Performance Laptop	441	$2,250.44	$993,006.65
Desktop/Workstation Assets				
A93002B	General Purpose Workstation	2,313	$1,236.90	$2,860,949.70
A90627G	High Performance Workstation	82	$2,161.32	$176,363.71
Total:		20,443		$33,461,597.70

The EAC method of discount cash-flow investment that converts cash flows into a series of uniform amounts was applied to laptops, desktop computers/workstations, and servers to determine when newly procured systems should be refreshed. It was determined that newly procured laptop computers should be refreshed every four years. To align better the 4-year operating life of a laptop computer, refreshing 25% of the inventory a year should be considered. It was also determined that newly acquired general-purpose desktops/workstations should be refreshed every four years and that high-performance desktops/workstations every five years. The number of assets to be

refreshed by TAMCN is shown in Figure 11 and the associated annual cost is shown in Figure 12. Costs of new assets are represented by the cost of purchasing new assets through the MCHS catalog in 2015.

Although the analysis indicates that servers could be operated into the seventh year, numerous articles and white papers identify several reasons why this is undesirable due to software supportability, security, energy cost, maintenance costs, and facility requirements. As technology advances, the number of servers required to support an organization is reduced. A further complication is that servers are not typically refreshed on a one-to-one basis: Cost benefits can be obtained by reducing the total number of servers in the inventory

B. LIMITATIONS

The data available on assets within the MDR provide a limited; the process of integrating data into usable procurement value of assets is reported, but the MDR does not currently provide information concerning when systems were actually purchased, information that would be useful in determining a depreciated value. Actual procurement dates would also provide for a better estimation on future refreshments costs.

Procurement costs of assets currently give only the baseline value for the asset. It was identified through the MCHS catalog that additional options include optical mice, monitors, storage, processors, and extended warranties. If these options are purchased when procuring an asset, their cost should be included in the procurement cost of the system in the MDR, which could assist in a more detailed assessment of assets in the inventory.

Operation, support, and maintenance cost for systems within the MDR was not readily determinable. Cost data listed was not complete and did not provide the level of detailed desired at the TAMCN level. Congressional budget reports and DOD budget reports were reviewed in an attempt to obtain cost data specific to the Marine Corps IT expenditures, but these provided only a high-level view of costs.

C. ADDITIONAL RESEARCH TOPICS

This research determined that a large cost was held in systems of systems. An EAC analysis can be conducted on these assets. If the acquisition cost of the system and the annual cost to operate and maintain the system are known, the analysis can be used to determine a life cycle for the total system. A similar model can be applied to leased devices. In this instance, instead of a single acquisition cost, the cost of the lease per year would be used within the model to aid in forecasting how long leased devices should be maintained before a new lease should be considered.

This thesis has focused primarily on data obtained from the MDR and commercial sources. Other studies can apply the same methodology to other accountability systems, such as DITPR-DON and DPAS, and such studies could identify differences in assets accounted for in the systems. Other research should be conducted in identifying the actual annual operation-and-support cost for Marine Corps IT assets. This information could then be applied to the EAC model. The findings in this study concerning server refreshment identified that several considerations that should be explored.

Software and services were not explored in this thesis, but these have significant costs associated with them and require detailed analysis unique to each. Further studies should assess their inventory and refreshment considerations.

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